# Livestock-Fishery Interaction Studies Tabor Creek, Nevada

NATIONAL FOREST SYSTEM · COOPERATIVE FORESTRY · FORESTRY RESEARCH
FOREST SERVICE · U.S. DEPARTMENT OF AGRICULTURE

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

# LIVESTOCK-FISHERY INTERACTION STUDIES
# TABOR CREEK, NEVADA

Progress Report 1 to the USDI Bureau of Land Management,
Nevada State Office, Reno, Nevada

July, 1979 to May, 1980

William S. Platts

Rodger Loren Nelson

Susan B. Martin

USDA - Forest Service, Intermountain Forest and Range Experiment Station,
Boise, Idaho

## PREFACE AND ACKNOWLEDGEMENTS

This progress report presents the results of our 1979 livestock-fishery interaction studies on Tabor Creek, Elko County, Nevada and informative background material from other sources. The specific information pertaining to the history and condition of the Tabor Creek area was obtained from material provided by Val Crispin, USDI Bureau of Land Management (BLM), Elko, Nevada, and includes the Nevada Department of Fish and Game publication (1963) describing the Mary's River Sub-basin. To limit distraction resulting from abundant and unwieldy referencing, this publication and official material on file with the BLM are referenced only when documentation is required. Additional appreciation is extended to Dave Young, Fisheries Biologist, USDI BLM, Sevier River Resource Area, Richfield, Utah for photographs illustrating field techniques; and to Osburne Casey, State Fishery Biologist, USDI BLM, Nevada State Office, Reno, Nevada for his efforts in coordinating this study. Fishery study field data and analysis is the product of work performed by the authors.

CONTENTS

# INTRODUCTION

There are 1.9 billion acres of land in the 48 conterminous United States, of which some 1.2 billion or 63 percent are rangelands. As of 1970, 69 percent of this acreage was grazed by domestic livestock. Although representing relatively little acreage themselves, streams of various sizes traverse this vast area. Unfortunately, they have often been ignored in rangeland planning.

The various classes of livestock utilize the range in different ways, necessitating different management practices to increase the compatibility of each class with riparian and aquatic habitat. Cattle, for example, will congregate on lesser slopes and bottomlands, while sheep, which are less dependent on water, usually favor steeper slopes and upland areas. Since sheep are also usually herded whereas cattle are not, management techniques to keep watersheds from being significantly altered differ between these two classes of livestock. The commonly used cattle management techniques are suspected to be less congenial than those used with sheep and are therefore the focus of this study.

Since the riparian zone, which forms the interface between the aquatic and the dryer terrestrial range ecosystems, is disproportionately important to both systems, application of effective management to this ecosystem is critical. Because of soil moisture, soil fertility, and related factors, the riparian ecosystem is more productive than the drier upland range, and its vegetation is more palatable. Coupled with this are other riparian features, such as gentler terrain, increased shade, and drinking water, which add to the attractiveness of this zone to cattle and can lead to preferential use.

The riparian zone also provides vitally important fishery habitat components, largely a result of streamside vegetation. Overhanging vegetation and undercut streambanks are an important source of protective cover, food, and shade. Shading prevents water temperatures from rising or fluctuating drastically, which can lead to shifts in species composition from salmonids to more tolerant species of non-game fish (Platts in press). In addition, detritus formed from terrestrial plants is a principal source of food for aquatic invertebrates and ultimately fish (Minshall 1967). Streamside vegetation also serves as a barrier to terrestrial pollutants and controls water velocity and streambank erosion. Since these features are all susceptible to damage by grazing animals, the needs of the indigenous fishery and the stockman can conflict.

Presently, there is an unfortunate dearth of factual information regarding the impacts of livestock grazing on riparian and aquatic ecosystems. As yet, only limited research has been directed toward lessening these impacts, though the constant increase in range use by cattle since the late 1800's has generally degraded rangelands and led to altered riparian habitat (Platts 1978). The resulting controversy surrounding the use of public rangelands by livestock and its potential conflicts with fishery needs has led to the emergence of livestock management as a national environmental issue (Leopold 1975, Platts 1978).

Working in this information vacuum, fisheries biologists have intuitively hypothesized that grazing of the riparian zone can significantly alter a fishery. Such alteration is believed to occur through physical modification of key stream features. Such changes as increased channel breadth, decreased depth and pool-riffle ratio, loss of vegetative and structural cover, accelerated bank erosion and sedimentation, and increased water temperature are expected to modify the character of the fishery. These changes, however, have yet to be sufficiently evaluated and identified for routine inclusion in management strategies. Additional studies that will provide solutions to these potential problems must be conducted (Meehan and Platts 1978; Platts 1978).

Against this background of limited information, it should come as no surprise that little help can be given the land manager in determining alternate strategies in situations where livestock are known to be exerting undue stress on the fishery. Valid analytical techniques for assessing the magnitude of livestock impacts have yet to be fully developed. Without these tools, it is difficult to determine whether changes in grazing patterns are indicated and what strategies should be implemented.

The Tabor Creek study is part of a comprehensive program to develop and test an array of field techniques which, when coupled with computerized analysis, will accurately identify the complex interactions that occur between different grazing intensities, grazing systems, classes of livestock, and fish. Field studies are currently being conducted on eleven sites in Idaho, two sites in Nevada, and two sites in Utah (Figure 1). The Idaho studies monitor impacts to streams in moist, forested, high mountain meadows, while the Utah and Nevada studies monitor impacts to streams in the more arid, sagebrush-type meadows. These studies are structured to allow time-trend analysis of livestock impacts on streams and will help the land manager select grazing systems that are as compatible as possible with fishery needs.

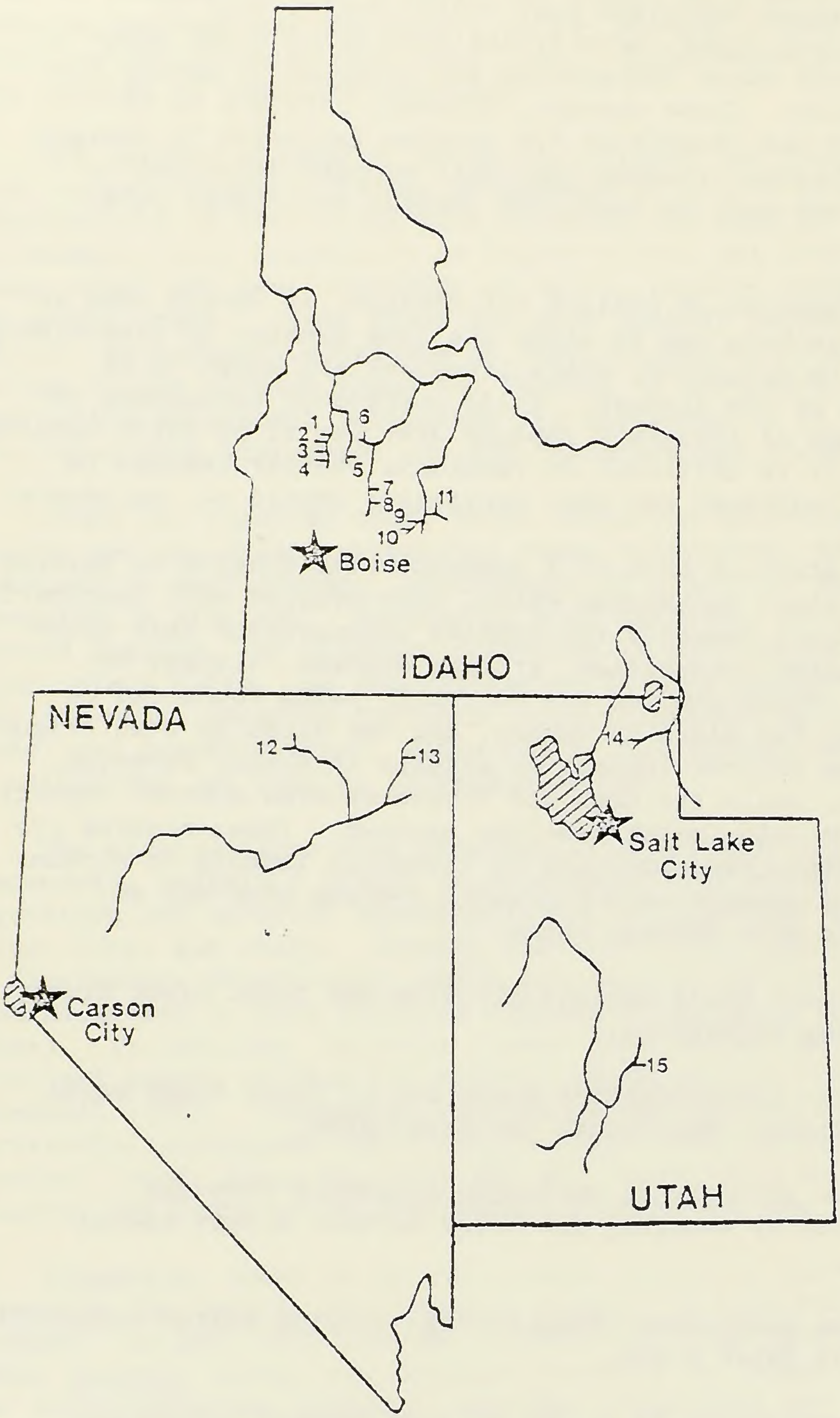
This progress report deals exclusively with the Tabor Creek Study, which has the following objectives:

1. Determine the rehabilitation potential of Tabor Creek based on past, present, and future use strategies.

2. Evaluate the efficacy of excluding livestock from the riparian zone by studying protected habitat within fenced exclosures.

3. Evaluate the continuous (season-long) grazing system currently in use along Tabor Creek.

4. Make recommendations as to the optimum grazing strategies relative to use and protection of riparian forage.




SALMON RIVER DRAINAGE

1 Stolle-Lower
2 Stolle-Cougar
3 Stolle-Guard
4 Stolle-Upper
5 Johnson Creek
6 Elk Creek
7 Bear Valley-Mace
8 Bear Valley-Upper
9 Frenchman-Lower
10 Frenchman-Upper
11 Pole Creek-Tributary

HUMBOLDT RIVER DRAINAGE

12 Gance Creek
13 Tabor Creek

BEAR RIVER DRAINAGE

14 Big Creek

SEVIER RIVER DRAINAGE

15 Otter Creek

Figure 1. Distribution of livestock-fishery study sites

STUDY AREA DESCRIPTION

## Physiography

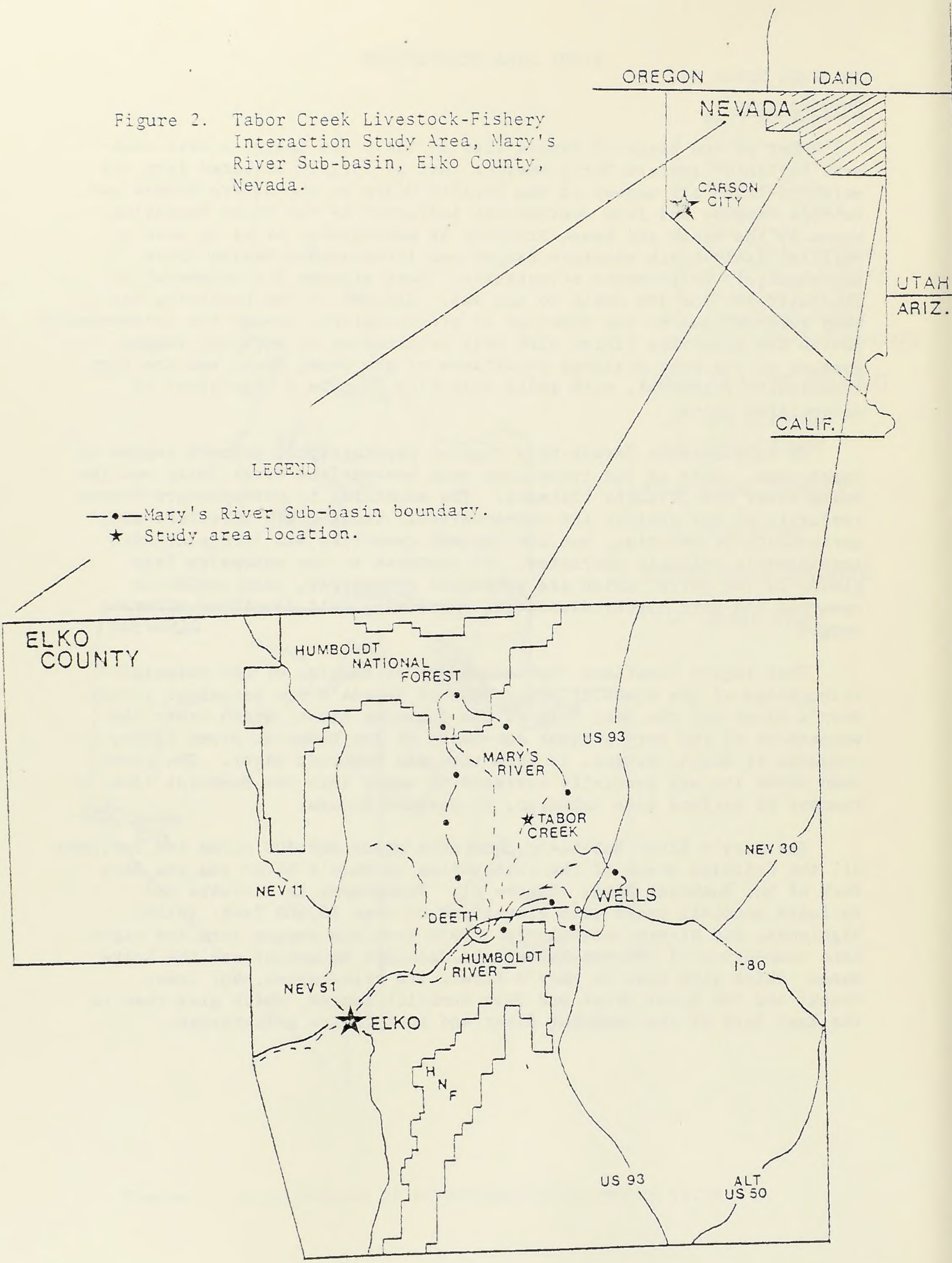
Most of the state of Nevada lies in the Great Basin, a vast semi-arid region of western North America that is largely isolated from the moisture-laden air masses of the Pacific Ocean by the Sierra Nevada and Cascade ranges, and from continental influence by the Rocky Mountains. Known as the Basin and Range Province by geologists, it is an area of parallel fault-block mountain ranges and intermontane basins in an approximately north-south orientation. Most streams are ephemeral or intermittent, and few drain to the sea. Erosion of the mountains has been retarded due to the shortage of precipitation, though the intermountain basins are generally filled with soil originating in adjacent ranges. Because of the poor drainage conditions of the Great Basin and the high evaporative potential, such soils typically contain a high level of accumulated salts.

In northeastern Nevada this regular physiographic pattern begins to break down. This is the transition zone between the Great Basin and the Snake River and Columbia Plateaus. The mountains in northeastern Nevada typically do not exhibit the characteristic fault-block structure and north-south orientation, but are instead dome-like and irregular with considerable volcanic character. In contrast to the extensive lava plains to the north, which are generally downwarped, this region is upwarped and more highly dissected, possessing well developed mountain ranges.

This region comprises the headwaters of several of the principal tributaries of the Humboldt River, one of Nevada's few perennial rivers. Mary's River and the East Fork of the Humboldt River, which drain the watersheds of the Mary's River sub-basin of the Humboldt River Basin, converge at Deeth, Nevada, to form the main Humboldt River. The river then winds its way generally westward to empty into the Humboldt Sink, a remnant of ancient Lake Lahontan, in western Nevada.

The Mary's River Sub-basin comprises about 649,800 acres and includes all the drainage areas of the tributaries of Mary's River and the East Fork of the Humboldt River (Figure 2). Topography is variable and includes mountain peaks with elevations of over 10,000 feet, valley highlands, and stream bottomlands. Four mountain ranges form the highland boundaries of the sub-basin: the Jarbidge Mountains and the Snake Range, which give rise to Mary's River, its tributaries, and Tabor Creek; and the Burnt Creek and East Humboldt Ranges, which give rise to the East Fork of the Humboldt River and most of its tributaries.

Figure 2. Tabor Creek Livestock-Fishery Interaction Study Area, Mary's River Sub-basin, Elko County, Nevada.



## Vegetation and Climate

Severe climatic conditions prevail over much of the Intermountain West and northeastern Nevada is no exception. Precipitation is sparse, winters are cold, and summers are hot. Precipitation, which averages only 8 to 9 inches at middle elevations, falls primarily as snow during winters in which the minimum January temperatures average only about 12°F (-11°C). The growing season is short, only about 3 months, and evaporation exceeds precipitation. Summer maximum temperatures average as high as 85°F (29°C), with minimal amounts of rain falling during this period; useable water during the growing season is chiefly derived from melting of the winter snowpack, and is supplemented by springs of water originating in other watersheds. On poorly drained soils, water stress is even greater because of accumulated salts. The resultant vegetation is largely restricted to xerophytic or halophytic communities, though the narrow streamside riparian zones support small mesophytic communities.

Ecologically, this region is part of Bailey's (1978) Intermountain Sagebrush Province. As suggested by the title, big sagebrush (*Artemesia tridentata*) is the dominant plant over many acres of range and frequently has a sufficiently well-developed grass understory to be considered a sagebrush-grass vegetation type. This is the vegetation of the upland range where plants are adapted to xeric conditions on well drained soils. Though sagebrush is relatively useless as livestock forage, bitterbrush (*Purshia tridentata*) is a common and palatable associate shrub. Desireable perennial bunchgrasses have been largely replaced in northeastern Nevada by such less desireable increasers as bottlebrush squirreltail (*Sitanion hystrix*) and the annual cheatgrass (*Bromus tectorum*), though Sandberg bluegrass (*Poa sandbergii*) is still common.

In the bottomlands and along the edges of semi-wet meadows, phreatophytic shrubs such as rubber rabbitbrush (*Chrysothamnus nauseosus*) gain importance. As alkalinity or salinity increases, even rabbitbrush gives way to greasewood (*Sarcobatus vermiculatus*) and saltgrass (*Distichlis stricta*).

The chief shrubs of the riparian zone at middle elevations are willow (*Salix* spp.) and wild rose.

## Agriculture

Elko County is largely rural, and livestock production is the principal industry. Sheep and cattle have both been important historically, but cattle have largely replaced sheep in recent years. The cattle industry is so important, in fact, that in 1961, 62 percent of Nevada's saleable cattle were produced in Elko County where 86 percent of the grazing land is federally-owned (Patterson and others 1969).

The Mary's River Sub-basin follows this pattern, with livestock production being the most important industry. As is typical in the intermountain region, however, the fertile floodplains and bottomlands are generally privately owned and cultivated for crop or hay production. Since this hay is primarily produced for use as winter livestock feed and cultivation removes land from use by livestock, the less arable federal lands are needed to provide spring through fall forage. As a result, the use of public domain lands is a locally important economic issue.

### Tabor Creek Exclosure

In 1968, a fenced livestock exclosure was constructed on Tabor Creek near the northern limit of the Tabor Creek field (Figure 3). Initially, the purpose of this structure was to protect sage grouse (*Centrocercus urophasianus*) habitat from livestock damage. Prior to the fall of 1976, however, the gates were left open and grazing was essentially unrestricted; since closing the gates in 1976, no known grazing has occurred within the exclosure. This structure now serves also as the protected habitat for this livestock-fishery interaction study.

## THE SITUATION

### Range Habitat

The land surrounding Tabor Creek is semi-arid shrubsteppe, typical of the cold desert biome in North America. Topographic relief is variable and includes mountain peaks, hillsides, and stream bottomlands. As is generally the case in ecosystems controlled by abiotic factors, the plant and animal communities are relatively simple and dominated by a few abundant and well-adapted species. In this case, the hillsides surrounding Tabor Creek support an almost uniform stand of big sagebrush, a woody shrub of relatively little value to livestock, with lesser amounts of bitterbrush and rabbitbrush, as well as greasewood on especially alkaline or saline sites. Growing among these shrubs are various grasses which provide the principal forage for livestock. Today, these grasses are primarily represented by Sandberg bluegrass, a Palouse-type grass, cheatgrass, and bottlebrush squirreltail though at one time bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), both typical Palouse prairie grasses, and Nevada bluegrass (*Poa nevadensis*) were the most important understory grasses.

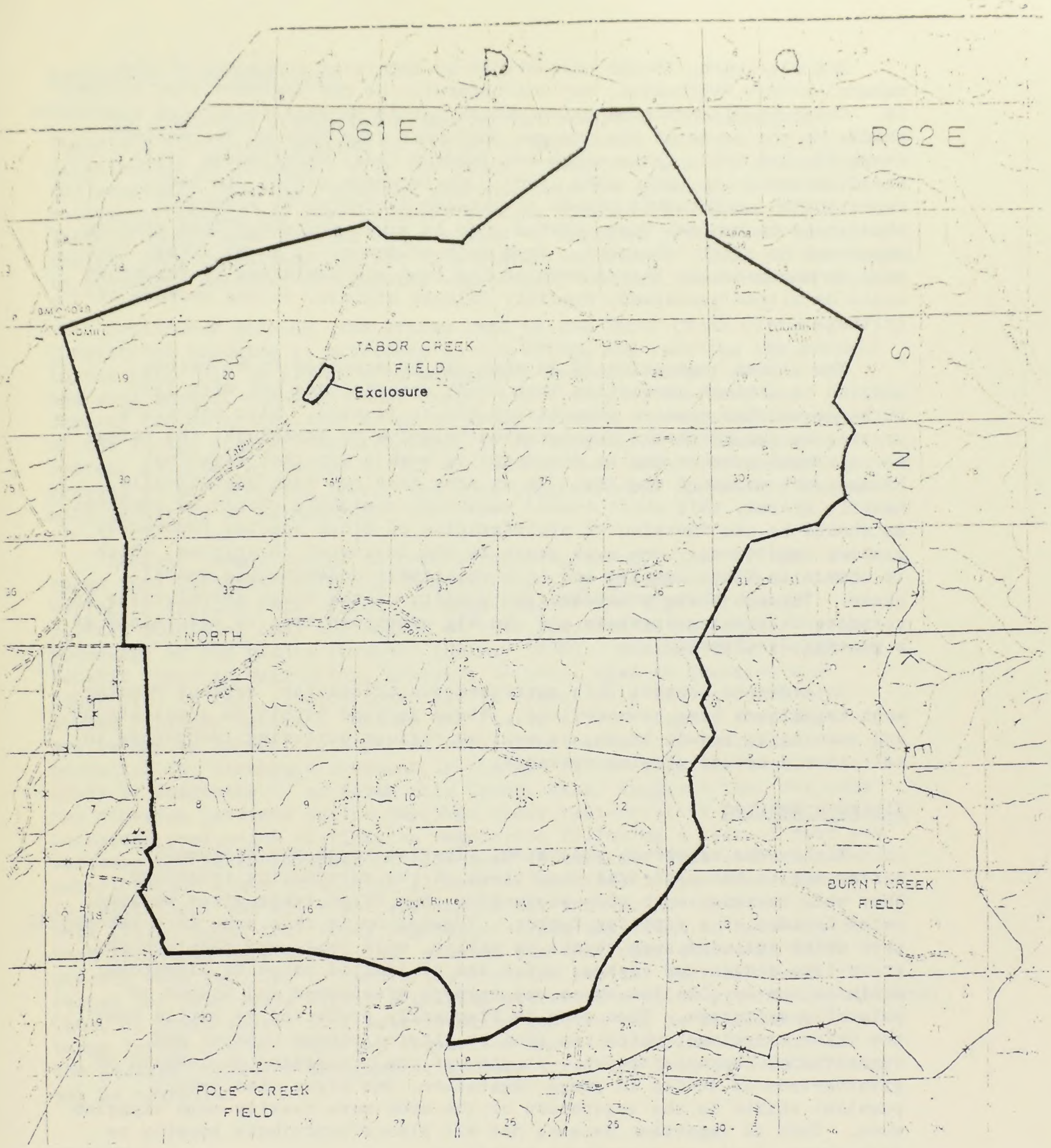



Figure 3. Tabor Creek Field and location of livestock exclosure.

Big sagebrush, though undoubtedly an important component of the natural climax vegetation, may not naturally be the dominant that it now is. Considerable evidence exists which points to grazing-induced vegetation shifts as the cause of its present dominance over much of the western range (Bailey 1978; Christensen and Johnson 1964; Christensen 1963; Stoddart and Smith 1955; USDA 1936). Christensen (1963), in fact, reporting on undisturbed stands of grasses dominated by bluebunch wheatgrass in central Utah, states that in areas protected from grazing sagebrush is rarely dominant. From such evidence, it seems likely that even in northeastern Nevada much of the land now dominated by sagebrush would be climax grassland, possibly Palouse prairie, in the absence of grazing.

The climax vegetation of an area can be expected to be better adapted to ambient conditions than other associations but with disturbance another species composition may be favored. With selective grazing on the palatable bunchgrasses relative to sagebrush, the normal successional process can be disrupted in such a way that sagebrush becomes the dominant species. In an area that has been historically heavily grazed, this shift toward sagebrush dominance should be expected, as should be the invasion or proliferation of other species favored by grazing conditions. One such grass is the increaser cheatgrass, which is common in Elko, County, and is a relatively undesireable annual grass. Through these processes the quality of the range deteriorates in response to grazing pressure and the big sagebrush type is maintained as a grazing disclimax.

In order to control this retrogressive succession, various management techniques have been devised. These include herbicide applications and burning to reduce brush, as well as various pasturing techniques to selectively reduce grazing pressure.

## Riparian Habitat

Within the sagebrush ecosystem, riparian zones are frequently narrow due to the semi-arid conditions of the surrounding rangeland. They are, however, much more productive than drier range sites because water is less of a limiting factor. Vegetation in this zone is a mesophytic type which includes such shrubs as willow, wild rose, and rabbitbrush; grass-like sedges and rushes, which are of limited value to livestock; while saline or alkaline areas may support greasewood and stands of palatable saltgrass. This zone is frequently preferred by cattle over the drier rangeland, which can lead to altered stream channel and vegetational characteristics. In view of the preceeding discussion of grazing-induced shifts in range vegetation, one might also expect parallel shifts in the vegetation of the even more heavily used riparian zone. This is important because not all plants contribute equally to fish cover, food, or streambank stability.

## Management Considerations

The preceding discussion brings up the question of management. There are five basic systems of livestock management used to control the distribution of livestock over the range. These systems are continuous (or seasonal), grazing, rotation grazing, deferred grazing, deferred rotation grazing, and rest-rotation grazing (Meehan and Platts 1978). These commonly used systems are designed to increase plant vigor and thereby help rangelands recover from historical abuse. Their effectiveness in promoting recovery of riparian vegetation, however, needs clarification.

Continuous grazing, the system used on the Tabor Creek pasture, consists of stocking an allotment in the spring and removing the animals in the fall. It is almost a no-management system, except, as the BLM has done several times on Tabor Creek, the timing of stocking and removal can be manipulated so as to avoid critical developmental stages of the forage plants. Nevertheless, it is frequently an inadequate system, as noted by Hormay (1970) who states that under continuous grazing at any stocking level, the more palatable and accessible plants will be killed or eliminated.

Another common system is rest-rotation grazing, which divides the range into pastures which are then systemically grazed and rested. If correctly applied this system can help restore the vigor of range plants, providing that the amount of rest required is determined by the phenology of the plants involved (Hormay 1970). Whether this system can benefit riparian vegetation, however, is still open to question and there are, in fact, indications that it cannot help the recovery of abused riparian habitat. Meehan and Platts (1978) suggest that this system may be harmful to riparian ecosystems because of increased potential for livestock movement in and use of the riparian zone. A study by Starostka [1/] on Seven Mile Creek, Utah, suggests that not only may riparian habitats not be improved under rest-rotation grazing, but increased production of riparian vegetation following a year of rest may increase the attractiveness of this zone to cattle. This could accelerate deterioration since structural alteration persists longer than changes in vegetation, and all plant species do not recover at the same rate. Duff (1978) found that woody vegetation along Big Creek in northeastern Utah recovered more slowly than grasses and that only six weeks of grazing were required to return the riparian habitat that had been rested for four years within a grazing-protected area to pre-rest conditions. Thus, it would appear that rest-rotation grazing may be beneficial to range forage but not riparian vegetation and, if riparian recovery is the desired object of management, systems involving long periods of rest may be required.

---

[1/] Starostka, Victor J. (n.d.) Some effects of rest-rotation grazing on the aquatic habitat of Seven Mile Creek. Report on file USDA, For. Serv., Richfield, Utah.

The three other systems either defer grazing for parts of the season or combine seasonal deferment and resting. None have clearly been shown to be effective in helping to rehabilitate riparian vegetation though some may be more successful than others. Only one system clearly stands out as being useful in riparian recovery: complete rest. This can be accomplished by fencing, which the BLM has done with the Tabor Creek exclosure, and, though it cannot be the final solution, it must be a consideration if high quality riparian habitat is to be conserved. The answer to this vexing problem should become clear as this study progresses since it will compare the effects of several grazing systems.

## GRAZING PATTERNS

### History

Prior to the discovery of gold in California in 1849, Nevada had remained largely unsettled, a vast expanse of mountain ranges and basins, belonging first to Mexico and acquired by the United States in 1848. Cattle were first brought into the state in the early 1840's, but these were few and largely passing through with parties of settlers and explorers. With the discovery of gold in California, however, large numbers of fortune seekers from the east found good passage along the course of the Humboldt River. This emergence of the Humboldt River as a major route to the gold fields led to the need for way-stations and settlements along this, the principal river in northern Nevada. With the local settlers came livestock and the first herds were loosed upon northeastern Nevada's virgin grasslands, giving birth to one of the states most important industries.

Early grazing use was extremely heavy, with itinerant bands of cattle and sheep competing with local ranchers for the desirable forage, and as late as 1880 there was still no law in Nevada that defined a "lawful fence." The problem of range abuse was recognized, however, and in 1909 a section of the Jarbidge Mountains, including the headwaters of Mary's River, was added to the Humboldt National Forest to protect important watersheds in these mountains. Extensive tracts of public land still remained open to unregulated use including most of the Mary's River Sub-basin, so, in 1919, Nevada enacted legislation requiring stockmen to own land before they could graze public range; this law was later repealed. Conditions continued to deteriorate as desirable forage was severely reduced or eliminated and undesirable species gained prominence. The problem on western rangelands was so severe that the federal government intervened again in 1934 with passage of the Taylor Grazing Act. This Congressional Act created the Grazing Service (later combined with the General Land Office to create the BLM) in the Department of the Interior to regulate grazing on public domain lands.

During the 90 years of grazing prior to formation of the Grazing Service, records of actual use by operators were inadequate. Thus, despite the fact that herds were taxed and fees were required to use lands set aside in national forests, it is difficult to accurately estimate how heavy use was in the Mary's River Sub-basin. Some insight into this question can be gained by considering the size of the cattle operation run in Elko County by John Sparks and A. J. Harrel, incorporated as the firm of Sparks and Harrel. With their headquarters in Wells, Nevada, they owned 200,000 acres from Wells north to the Snake River and in 1884 branded 14,000 calves; their breeding herd in Elko County numbered some 70,000 animals. This firm, though definitely the largest in Elko County, was only one of several very large operations which, when considered with the many itinerant and tramp herds in the area, paint a picture of a severely overstocked range with little effective regulation outside of national forest reserves.

The more recent records used for adjudication under the Taylor Grazing Act are more accurate and indicate that during the period 1929-1934 the area from Mary's River to the crest of the Snake Mountains and from the Humboldt River to Hot Creek on the north (approximately the eastern three-fourths of the sub-basin and including Tabor Creek, Figure 2) domestic livestock numbers were on the order of 27,000 annually. Such heavy use indicates that the range continued to be overused and, though the Grazing Service did much to ameliorate range conditions, range quality continued to decline. As a result, the Metropolis Unit, which comprised this part of the sub-basin, was adjudicated in 1957 and the BLM imposed a 39 percent reduction in use over the succeeding three years.

In 1958 the BLM consummated a land exchange with Marble Ranches (Mary's River Ranch) which placed the upper portion of the Tabor Creek watershed under private ownership; commencing approximately 1 July, this area has been grazed every summer since.

## Present and Future Trends

Grazing by allotment, an arrangement in which certain range subdivisions are designated for use by authorized operators, was instituted in the Tabor Creek area in 1961. The BLM land along Tabor Creek, along with that along Burnt Creek, was placed in the Barlow area of use. Season-of-use dates were then set in 1965, designating these two pastures as summer range with a season-of-use from 1 June to 15 September; stocking of the Tabor Creek field was set at 1,350 head for 4,725 animal unit months (AUM's). As can be seen in Table 1, this pattern was modified prior to the 1970 grazing season with permitted use increased to 1,350 head for 4,865 AUM's. During the 1970's the pattern fluctuated with the permitted stocking level being raised to 2,122 head for 7,639 AUM's accompanied by a season-of-use change to the period 1 July to 20 October, and in 1979 the turn-off date was pushed up to 30 September reducing use to 6,366 AUM's; at all times, use remained below the estimated carrying capacity of 8,100 AUM's. This general pattern is expected to continue, with the possibility of some reductions in animal numbers.[1/] Grazing has not occurred within the exclosure on Tabor Creek since the fall of 1976.

[1/] Crispin, Val. 1980. Personal correspondence. USDI Bur. Land Manage., Elko, Nevada.

Table 1. Tabor Creek Pasture Grazing Management 1970-1980 1/

| GRAZING PARAMETER | | YEAR 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 2/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated Capacity (AUM's) | | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 | 8100 |
| Stock Class | | cattle | cattle | cattle | cattle | cattle | cattle | cattle | cattle | cattle | cattle | cattle |
| Grazing System | | PWC 3/ | PWC | PWC | PWC | PWC | PWC | PWC | PWC | PWC | PWC | PWC |
| Grazing Season | | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 6/1 - 9/15 | 7/1 - 10/20 | 7/1 - 9/30 | 7/1 - 9/30 |
| Permitted Stocking Level | Numbers | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 | 2122 | 2122 | 2122 |
| | AUM's | 4865 | 4865 | 4865 | 4865 | 4865 | 4865 | 4865 | 4865 | 7639 | 6366 | 6366 |
| Actual Stocking Level | Numbers | | | | | | | | | | | |
| | AUM's | | | | | | | | | | | |
| Range Vegetation Use | | | | | | | | | | | | |
| Riparian Vegetation Use | Inside Exclosure | | | | | | | 0 | 0 | 0 | 0 | 0 |
| | Outside Exclosure | | | | | | | | | | 67.7 | |

1/ Data supplied by Val Crispin, BLM, Elko, Nevada.

3/ Pasture-wide continuous.

## METHODS

### General

Ongoing studies are presently being conducted on a total of 15 study sites, 11 in Idaho and two each in Nevada and Utah. These sites are generally in meadow environments on National Forest lands, and lower elevation sagebrush-type meadows on Bureau of Land Management lands. The purpose of these studies is to refine techniques for monitoring and assessing the impacts of livestock on riparian and aquatic ecosystems.

The basic design of each study site is to stratify 1810 feet of stream by subdividing it into 181 transects placed at 10-foot intervals along the stream. The stream is then divided into three 600-foot sections, with the middle section fenced to provide an area for manipulation, the up- and downstream sections serving as controls. Livestock are either introduced to or excluded from the fenced area depending on the needs of the study. Annual monitoring of each section then provides information on each relative to the others over the course of several seasons of use. For Tabor Creek, this basic design has been modified, as shown in Figure 4, to accommodate the large size of the exclosure.

The data collected fall into four basic categories: 1) geomorphic/aquatic, 2) riparian or streamside, 3) hydrologic, and 4) biological, and include the following:

#### Geomorphic/Aquatic

1. Substrate materials
2. Substrate embeddedness
3. Stream width and depth
4. Bank-stream contact water depth
5. Pool width, quality, and feature
6. Riffle width
7. Streambank angle
8. Streambank undercut
9. Fisheries environment quality rating

#### Riparian

10. Streamside habitat type
11. Streambank stability
12. Overhanging vegetation
13. Vegetation use (ocular and herbage meter)
14. Streambank alteration (natural and artificial)

#### Hydrologic

15. Stream profile
16. Stream gradient
17. Stream velocity

#### Biological

18. Fish species composition, number and biomass

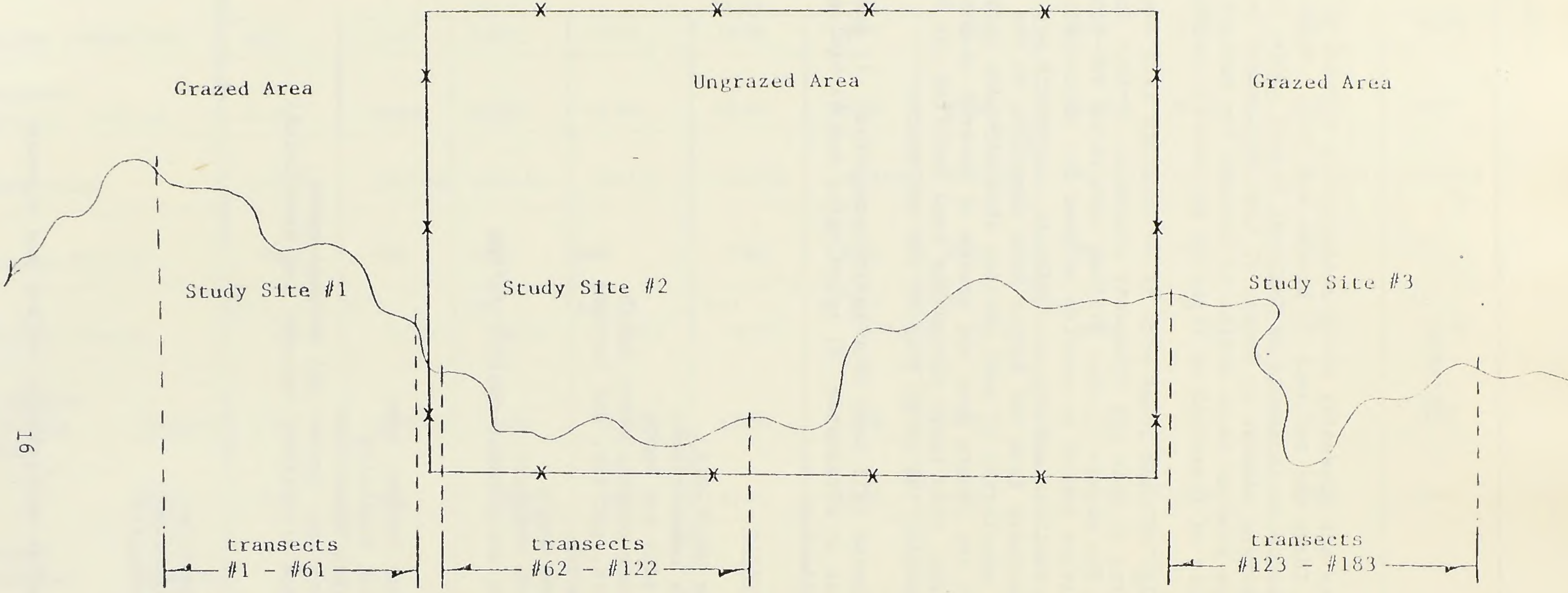



Figure 4. Schematic diagram of the Tabor Creek Livestock-Fishery Interaction Study area.

A brief description of the procedures used in this study follows. More detailed descriptions can be found in Morris and Others (1976), Neal and Others (1976), Platts (1974), Platts (1976), and Ray and Megahan (1978).

## Geomorphic/Aquatic Analysis

These measurements describe the structural characteristics of the stream being studied and can therefore be used to document livestock induced changes in the stream channel when monitored over several grazing seasons.

Substrate materials are classified into five classes by visually projecting each one-foot division of a measuring tape to the streambed surface and assigning the major observed sediment class to each division. Sediments are classified as boulder, rubble, gravel, and fine sediment. Stream channel substrate embeddedness measures the gasket effect of fine sediment around the larger size substrate particles and is ranked numerically from 1 (highly embedded) to 5 (slightly embedded). Instream vegetation cover is a direct measurement of the vegetative cover on the channel intercepted by the transect.

Stream width is a horizontal measurement of that area of the transect covered by water. Stream depth is the average of four water depths taken at equal intervals across the transect from the water surface to the channel bottom. Water depth at the intersection of the streambank or stream channel with the edge of water is a direct measurement from water surface to channel bottom. Pools are classified as that area of water column usually deeper than riffles and slower in water velocity; riffle is the remainder of the column. Pool quality rating is based on the pool's ability to provide certain rearing requirements needed by fish, particularly size, depth, and cover, and is ranked from 1 (poor) to 5 (high quality). The streambank angle is measured with a clinometer (Photographs 1 and 2) which determines the downward slope of the streambank to the water. Streambank undercut is a direct horizontal measurement, parallel to the stream channel, of the erosion of the bank at the water influence area. Fisheries environment quality ratings depict the general ability of the bank-stream contact zone to provide the conditions believed necessary for high fish standing crops. This rating is a function of both stream characteristics at the bank (pool or riffle) and available cover and is ranked from 1 (poor) to 5 (excellent).

## Riparian Analysis

These measurements describe the riparian interface between the aquatic and terrestrial ecosystems. Annual monitoring of these data after the grazing season illustrates changes in many critical fishery habitat parameters.

Photograph 1. Measurement of bank angle with an undercut bank. Angle is about 45°.

Photograph 2. Close up of clinometer showing measurement of bank angle with an undercut bank. Angle is about 45°.

Streamside cover categorizes the dominant vegetation as exposed, brush, grass, or tree (numerically ranked 1 to 4). Streambank alteration assessment quantifies the natural and artificial changes occurring to the streambank and is ranked in percent alteration. Streamside cover stability rates the ability of the streambanks to resist erosion and is ranked from 1 (poor) to 4 (high quality). Vegetative overhang (Photographs 3 and 4) directly measures the length of the vegetation overhanging the water column within 12 inches of the water surface. Habitat rating is based on the belief that sand banks are of least importance to fish, while brush-sod banks are of the greatest value. Intermediate types are ranked accordingly by dominant and subdominant characters. Measurement of vegetation use is done both by ocular assessment and with an herbage meter.

### Herbage

In order to provide a quantitative complement to an ocular vegetation use assessment, a Neal Electronics Model 18-2000 herbage meter is used to measure standing vegetation. These readings are taken at approximately every fourth transect, and linear regression analysis against clipped plots provides a quantitative measure of forage biomass and use.

### Electrofishing

Fish populations are sampled with either battery powered, portable, backpack mounted electrofishers or with gasoline powered, motor energized units. Salmonids are counted, measured, and weighed, while non-salmonids are counted and weighed as a group. All are handled as carefully as practicable, and promptly returned to the stream alive.

### Hydraulic Geometry

Ten transects in the central section of each 600-foot stream reach are used for hydraulic geometry measurement. The data obtained here allows us to generate a channel cross-section map. Periodic measurement over the course of the study shows quantitative changes due to erosion and deposition of channel materials. The streams are surveyed to detect changes in their relative positions, and the water surface is surveyed to allow monitoring of changes in channel gradient.

## RESULTS

Results of the geomorphic/aquatic analysis for Tabor Creek in 1979 are listed in Table 2. Riparian information for the stream is given in Table 3. Since grazing has been eliminated in Site 2 (treatment area) by the BLM exclosure from 1976 to the present, it is not surprising that the data collected for the first year of this study indicate significant differences in several parameters between the ungrazed (Site 2) and the grazed (Sites 1 and 3) sites.

Photograph 3. Measuring overhanging vegetation. Such overhang is an important source of fish cover.

Photograph 4. Measuring overhanging vegetation. Note that this shrub overhangs the stream about 1.5 feet.

Table 2. Results of geomorphic/aquatic analysis for Tabor Creek, Nevada in 1979 (8/14/79). Sites 1 and 3 are grazed, while site 2 is ungrazed.

| Variable | Site 1 | | Site 2 | | Site 3 | | Overall | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Interval | Mean | Interval | Mean | Interval | Mean | Interval |
| Stream width (ft)* | 13.9 | 12.9 - 14.9 | 10.3 | 9.2 - 11.3 | 12.3 | 11.3 - 13.3 | 12.2 | 11.6 - 12.8 |
| Stream depth (ft)* | 0.33 | 0.29- 0.37 | 0.43 | 0.39- 0.47 | 0.37 | 0.33- 0.41 | 0.38 | 0.35- 0.40 |
| Riffle (percent) | 81.4 | 75.9 - 86.9 | 79.1 | 73.5 - 84.6 | 85.0 | 79.6 - 90.5 | 81.9 | 78.7 - 85.0 |
| Pool (percent) | 18.6 | 13.1 - 24.1 | 20.9 | N.A.[1] | 15.0 | 9.5 - 20.4 | 18.1 | 14.9 - 21.3 |
| Bank angle (deg) | 113.8 | 106 -122 | 109.9 | 102 -118 | 111.7 | 104 -119 | 111.8 | 107 -116 |
| Bank undercut (ft) | 0.13 | 0.06- 0.18 | 0.18 | 0.11- 0.23 | 0.20 | 0.14- 0.26 | 0.17 | 0.13- 0.20 |
| Bank water depth (ft) | 0.15 | 0.11- 0.19 | 0.15 | 0.11- 0.19 | 0.10 | 0.06- 0.14 | 0.13 | 0.11- 0.15 |
| Embeddedness* | 3.3 | 3.1 - 3.5 | 2.8 | 2.6 - 3.0 | 3.7 | 3.5 - 3.9 | 3.3 | 3.2 - 3.4 |
| Boulder (percent) | 0.6 | 0.1 - 1.0 | 0.9 | 0.5 - 1.4 | 1.0 | 0.6 - 1.5 | 0.9 | 0.61- 1.1 |
| Rubble (percent)* | 31.1 | 25.7 - 36.5 | 19.8 | 14.3 - 25.4 | 22.8 | 17.3 - 28.2 | 24.6 | 21.5 - 27.8 |
| Gravel (percent)* | 50.2 | 43.4 - 56.9 | 45.7 | 38.8 - 52.6 | 58.3 | 51.5 - 65.1 | 51.5 | 47.5 - 55.4 |
| Fines (percent) | 13.9 | 11.5 - 15.9 | 20.3 | 17.2 - 23.1 | 10.2 | 7.3 - 12.7 | 14.4 | 12.9 - 15.8 |
| Instream cover (ft)* | 0.19 | 0 - 0.5 | 0.70 | 0.42- 0.78 | 0.37 | 0 - 0.65 | 0.42 | 0.26- 0.58 |
| Fisheries rating* | 1.3 | 1.1 - 1.5 | 1.7 | 1.5 - 1.9 | 1.4 | 1.2 - 1.6 | 1.5 | 1.4 - 1.6 |

*Significant at 5% level.

[1] N.A. - Not Available

Table 3. Results of riparian analysis for Tabor Creek, Nevada in 1979 (10/8/79). Sites 1 and 3 are grazed, while site 2 is ungrazed.

| Variable | Site 1 | | Site 2 | | Site 3 | | Overall | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Interval | Mean | Interval | Mean | Interval | Mean | Interval |
| Bank cover stability* | 1.7 | 1.5 - 1.8 | 2.3 | 2.1 - 2.5 | 1.9 | 1.7 - 2.1 | 1.9 | 1.8 - 2.1 |
| Habitat type | 13.7 | 12.6 - 14.9 | 13.0 | 11.8 - 14.2 | 13.1 | 11.9 - 14.3 | 13.3 | 12.6 - 13.9 |
| Vegetation use (%)* | 68.3 | 65 - 72 | 0 | 0 - 3.8 | 67.1 | 63 - 71 | 45.6 | 43 - 48 |
| Alteration-natural (%)* | 22.4 | 19 - 26 | 27.3 | 24 - 31 | 23.7 | 20 - 27 | 24.5 | 23 - 26 |
| Alteration-artificial (%)* | 14.1 | 12 - 16 | 7.1 | 5 - 9 | 10.9 | 9 - 13 | 10.7 | 9.6 - 11.9 |
| Vegetation overhang (ft)* | 0.11 | 0 - 0.2 | 0.42 | 0.3 - 0.5 | 0.26 | 0.15- 0.38 | 0.26 | 0.19- 0.33 |

*Significant at 5% level.

## Geomorphic/Aquatic Analysis

The stream is narrower and deeper in the ungrazed area. The embeddedness rating is lower, indicating a somewhat higher gasket effect of fine sediment around larger channel materials in the ungrazed site. The channel substrate measurements listed in Table 2 are at this time only a general indication of the composition of the Tabor Creek channel. More accurate results will be presented later after additional computer runs, as we still have some problems in the computer program. It appears that the percentages of rubble and gravel in the ungrazed channel area are significantly lower than in the grazed areas, while the percentage of fine sediments may be higher in the ungrazed site (no test of significance has been made on this figure yet). The higher gasket effect and higher percentage of fine sediment in the ungrazed area may be from material settling out. There is a higher percentage of pools in the ungrazed section which may allow suspended material to settle out of the water column in that region. The greater amount of instream vegetative cover and higher fishery rating in the ungrazed channel area indicate a habitat more suitable for fish than in the grazed areas.

## Riparian Analysis

Riparian conditions in the Tabor Creek study area appear to be more stable in the ungrazed site versus the grazed sites. Bank cover stability is better in the ungrazed area, which suggests the streambanks are less likely to erode. The vegetation use in the ungrazed area was essentially zero, while it was nearly 70 percent in the grazed areas; the existence of a confidence interval around zero for site 2 is the result of grazing along the fenceline. Vegetation overhang in the ungrazed area was higher, indicating more plant growth was present to provide shade and cover for fish in the stream. Streambank alteration from artificial causes was significantly less in the ungrazed area than in the grazed sites, while natural alteration rated somewhat higher. This is to be expected, as artificial alteration in the grazed areas often masks some of the natural alteration. When no artificial alteration is present, the natural alteration is more easily evaluated.

## Herbage Analysis

An electronic capacitance meter was used to measure vegetation in the grazed and ungrazed site on Tabor Creek. The regression results for plots clipped within the study sites are shown in Figure 5 and Table 4. Calculated vegetation production levels for sites 1 and 2 are listed in Table 5.

The calibration curve in Figure 5 shows that wet vegetation weights correlate highly with herbage meter readings, with 89 percent ($r^2$) of the variability in weight due to regression on the meter readings. The absence of grazing in site 2 is readily apparent in the high amount of vegetative biomass remaining in this area (1997 lb/acre) and the effects of grazing show up in the lower vegetation biomass for site 1 (216 lb/acre).

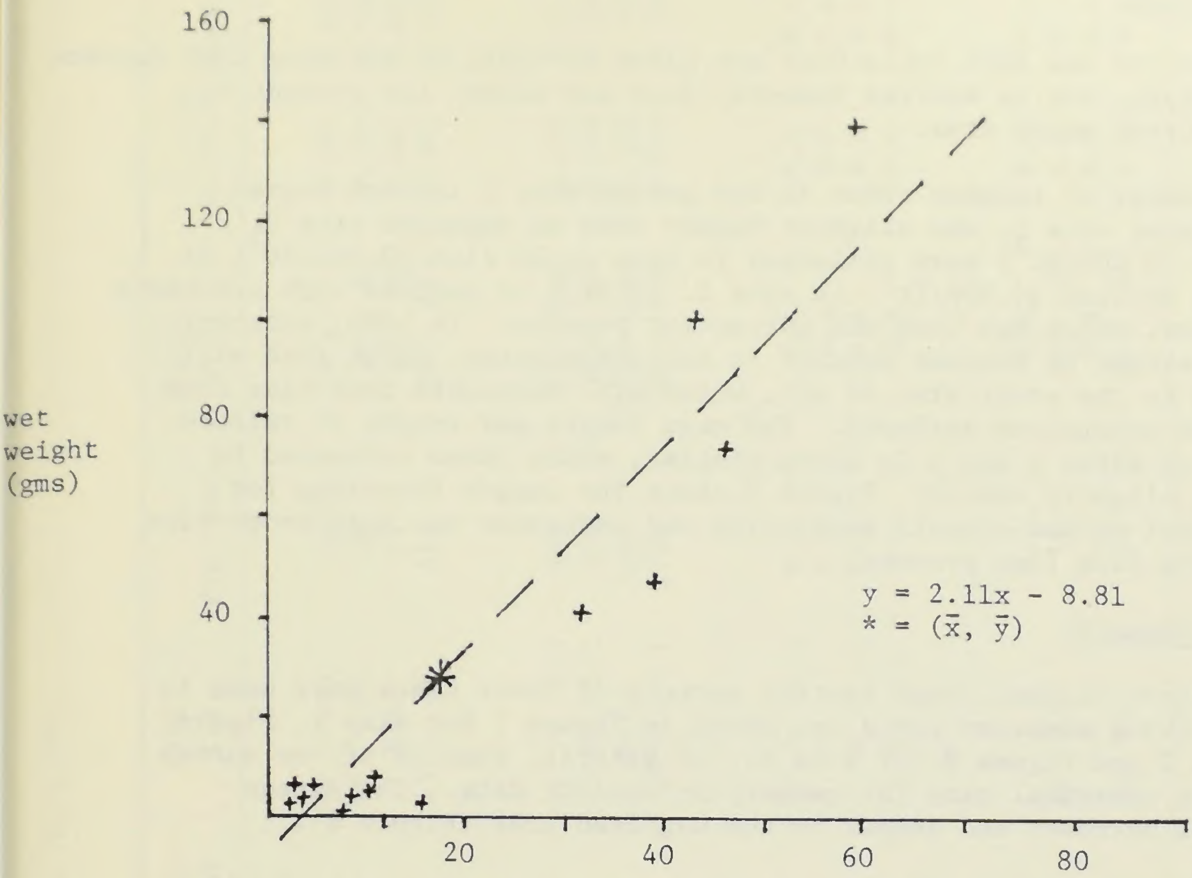



Figure 5. Regression curve of vegetation weight to meter readings for Tabor Creek (sampled 10/8/79).

Table 4. Herbage analysis for calibration data. Variables fit the regression equation $y = a + bx$.

| | Variable | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | $\bar{x}$ | $\bar{y}$ | a | b | Avg. Prod. (lb/acre) | r | $r^2$ |
| 1979 | 17.2 | 27.4 | -8.81 | 2.11 | 1315 | 0.94 | 0.89 |

Table 5. 1979 herbage analysis results for grazed and ungrazed sites.

| | Variable | | |
|---|---|---|---|
| Study Site | Meter Reading | Weight (gm) | Production (lb/acre) |
| Site 1 (grazed) | 6.3 | 4.5 | 216 |
| Site 2 (ungrazed) | 23.9 | 41.6 | 1997 |

Electrofishing

Results of the fish collection are given in Table 6, and show that rainbow trout, sculpin, and in smaller numbers, dace and sucker are present in the Tabor Creek study area.

The number of rainbow trout in the grazed site 3 is much higher than in grazed site 1, and slightly higher than in ungrazed site 2. Fifty fish ($0.007/ft^2$) were collected in site 3, 20 fish ($0.002/ft^2$) in site 1 and 39 fish ($0.006/ft^2$) in site 2. Site 3 is stocked with catchable size rainbow, which may bias the collection results. In 1980, hatchery fish will either be stocked equally in all three sites, or no fish will be stocked in the study area at all, which will eliminate this bias from future fish population analysis. The mean length and weight of rainbow collected in sites 1 and 3 is quite similar, while those collected in site 2 are slightly smaller. Figure 6 shows the length frequency for rainbow trout in the overall study area and indicates the high proportion of catchable size fish present.

Hydraulic Geometry

The first channel cross section surveys of Tabor Creek were made in 1979. Resulting computer plots are shown in Figure 7 for site 1, Figure 8 for site 2 and Figure 9 for site 3. In general, results of the survey support the numerical data for geomorphic/aquatic data. The stream tends to be narrower and deeper in the ungrazed area (Figure 8).

Mean velocities for those transects surveyed are listed in Table 7.

Table 7. Mean velocity readings for cross section transects, Tabor Creek (8/13/79).

| Site 1 Transect | Mean Velocity (ft/sec) | Site 2 Transect | Mean Velocity (ft/sec) | Site 3 Transect | Mean Velocity (ft/sec |
|---|---|---|---|---|---|
| 29 | 1.09 | 90 | 1.52 | 148 | 1.57 |
| 30 | 1.07 | 91 | 0.86 | 149 | 1.25 |
| 31 | 0.86 | 92 | 1.29 | 150 | 1.55 |
| 32 | 1.01 | 93 | 0.77 | 151 | 0.86 |
| 33 | 0.89 | 94 | 1.09 | 152 | 0.76 |
| 34 | 1.85 | 95 | 0.59 | 153 | 2.16 |
| 35 | 2.02 | 96 | 0.01 | 154 | 1.38 |
| | | | | 155 | 1.53 |
| | | | | 156 | 1.51 |

Table 6. Fish collection data for Tabor Creek, Nevada in 1979 (8/14/79).

| | Total No. Collected | (mm) Ave. Length | 95% C.I.[1/] | (gm) Ave. Weight | 95% C.I. | Pop. Est. | 95% C.I. | No./ft$^2$ | No./m$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | | | | | | | | | |
| Site 1 | 20 | 179.3 | 158-201 | 73.7 | 47 -100 | 20[2/] | N.A.[3/] | 0.002 | 0.026 |
| Site 2 | 39 | 171.9 | 157-187 | 70.8 | 49 - 92 | 39 | 39- 41 | 0.006 | 0.068 |
| Site 3 | 50 | 179.5 | N.A. | 76.7 | N.A. | 52 | 50- 56 | 0.007 | 0.073 |
| Overall | 109 | 176.8 | 168-186 | 74.0 | 63 - 85 | 111 | 109- 115 | 0.005 | 0.053 |
| Sculpin | | | | | | | | | |
| Site 1 | 212 | N.T.[4/] | N.T. | 4.9 | 4.5- 5.3 | 227 | 214- 240 | 0.025 | 0.273 |
| Site 2 | 305 | N.T. | N.T. | 4.5 | 3.8- 5.2 | 352 | 323- 381 | 0.049 | 0.530 |
| Site 3 | 921 | N.T. | N.T. | 2.2 | N.A. | 1166 | 1080-1252 | 0.125 | 1.340 |
| Overall | 1438 | N.T. | N.T. | 3.1 | 2.5- 3.7 | 1724 | 1644-1804 | 0.065 | 0.704 |
| Dace | | | | | | | | | |
| Site 1 | 2 | N.T. | N.T. | 3.0 | 1.7- 4.3 | N.A. | N.A. | N.A. | N.A. |
| Site 2 | 0 | N.T. | N.T. | 0 | 0 | N.A. | N.A. | N.A. | N.A. |
| Site 3 | 1 | N.T. | N.T. | 6.0 | N.A. | N.A. | N.A. | N.A. | N.A. |
| Overall | 3 | N.T. | N.T. | 4.0 | 0- 8.3 | N.A. | N.A. | N.A. | N.A. |
| Sucker | | | | | | | | | |
| Site 1 | 0 | N.T. | N.T. | 0 | 0 | N.A. | N.A. | N.A. | N.A. |
| Site 2 | 14 | N.T. | N.T. | 30.5 | 26 -35 | 14 | 14- 16 | N.A. | N.A. |
| Site 3 | 0 | N.T. | N.T. | 0 | 0 | N.A. | N.A. | N.A. | N.A. |
| Overall | 14 | N.T. | N.T. | 30.5 | 26 -35 | 14 | 14- 16 | N.A. | N.A. |

[1/] C.I. - confidence interval

[2/] Actual number collected, no population estimate available

[3/] N.A. - data not available

[4/] N.T. - data not taken

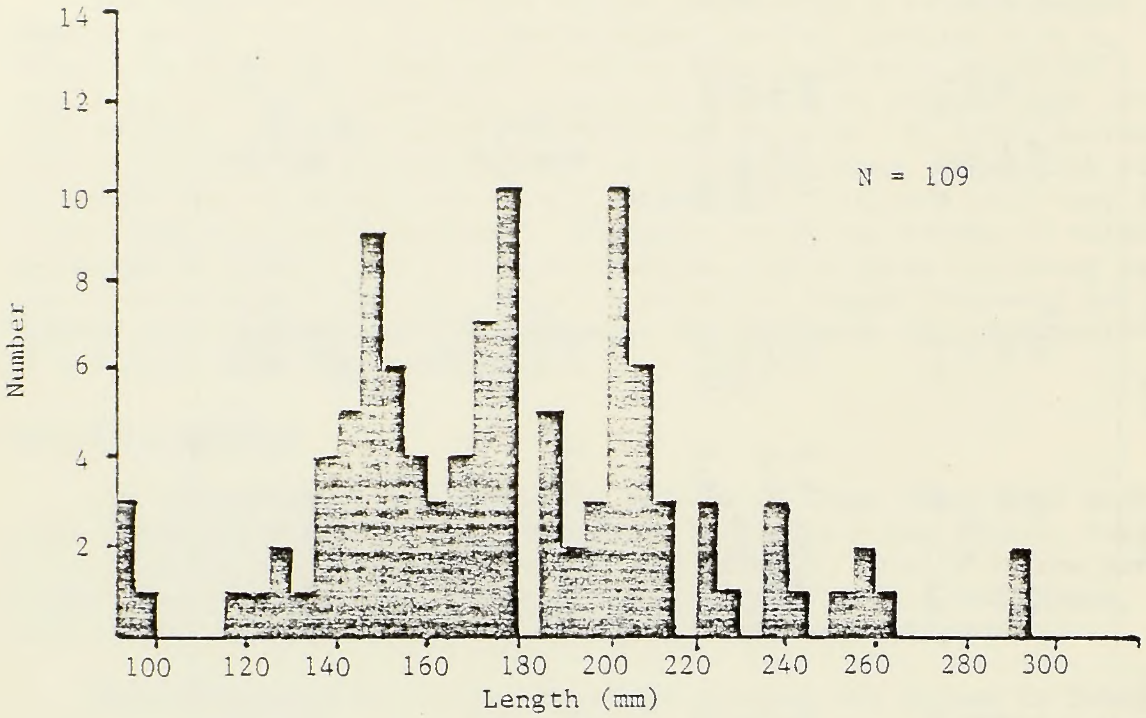



Figure 6. Length frequency of rainbow trout in the Tabor Creek study area (sampled 8/14/79).

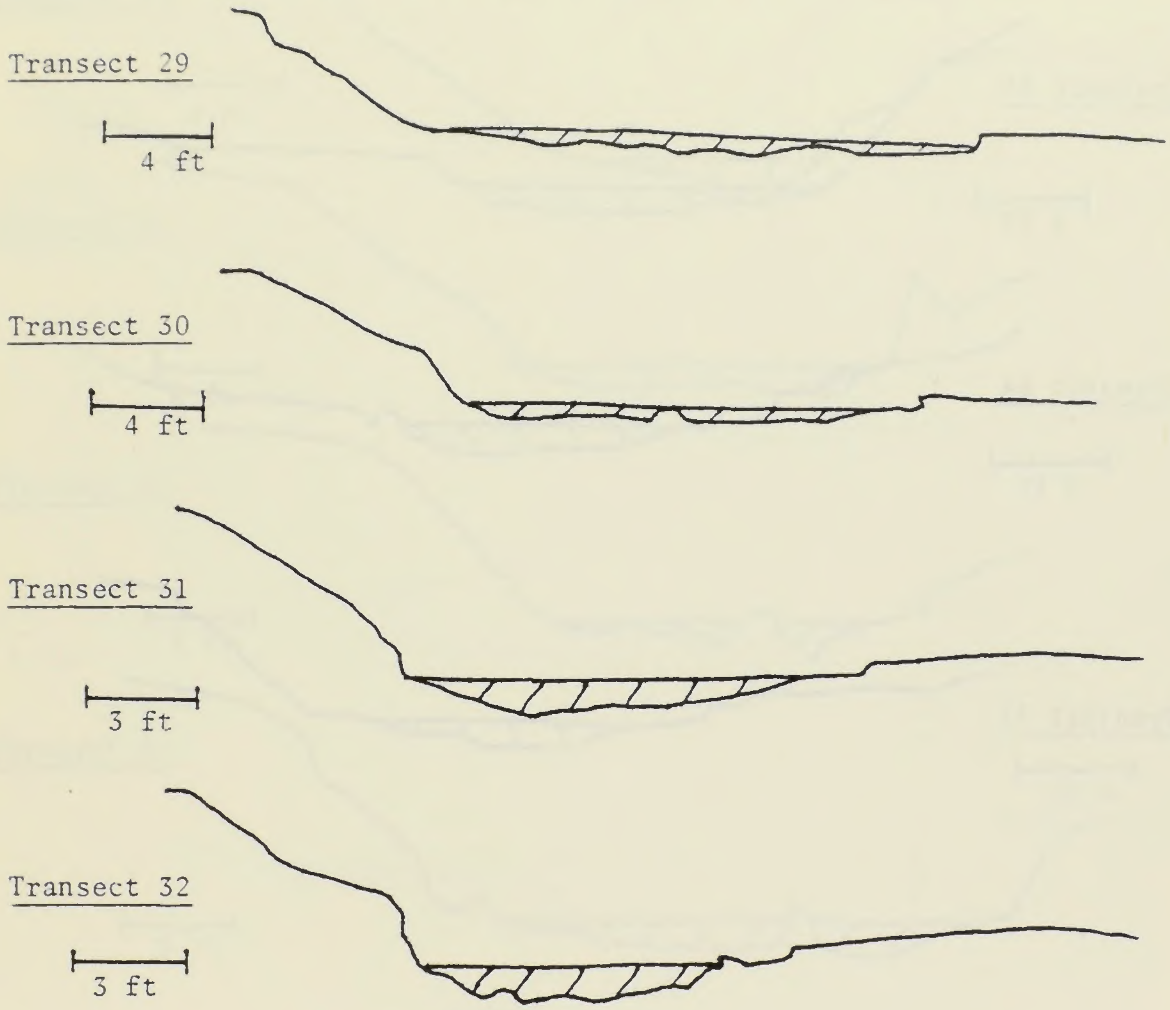



Figure 7. Channel cross sections for site 1, Tabor Creek in 1979.

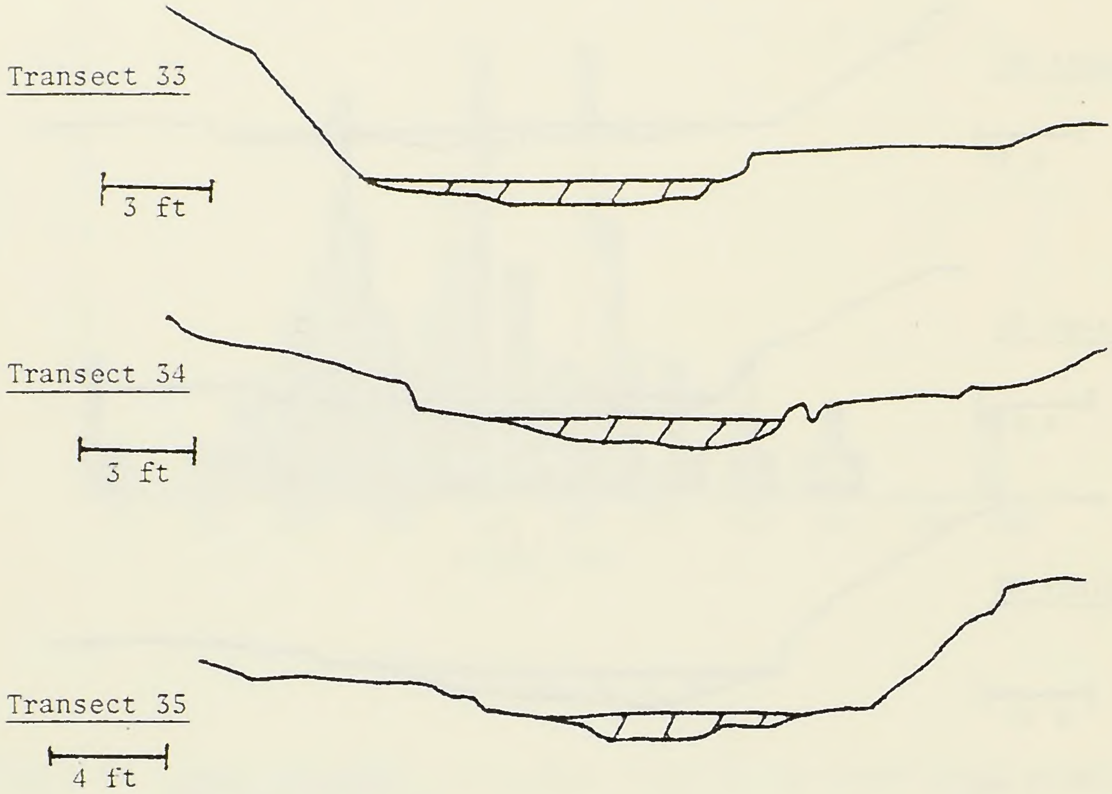



Figure 7. Continued.

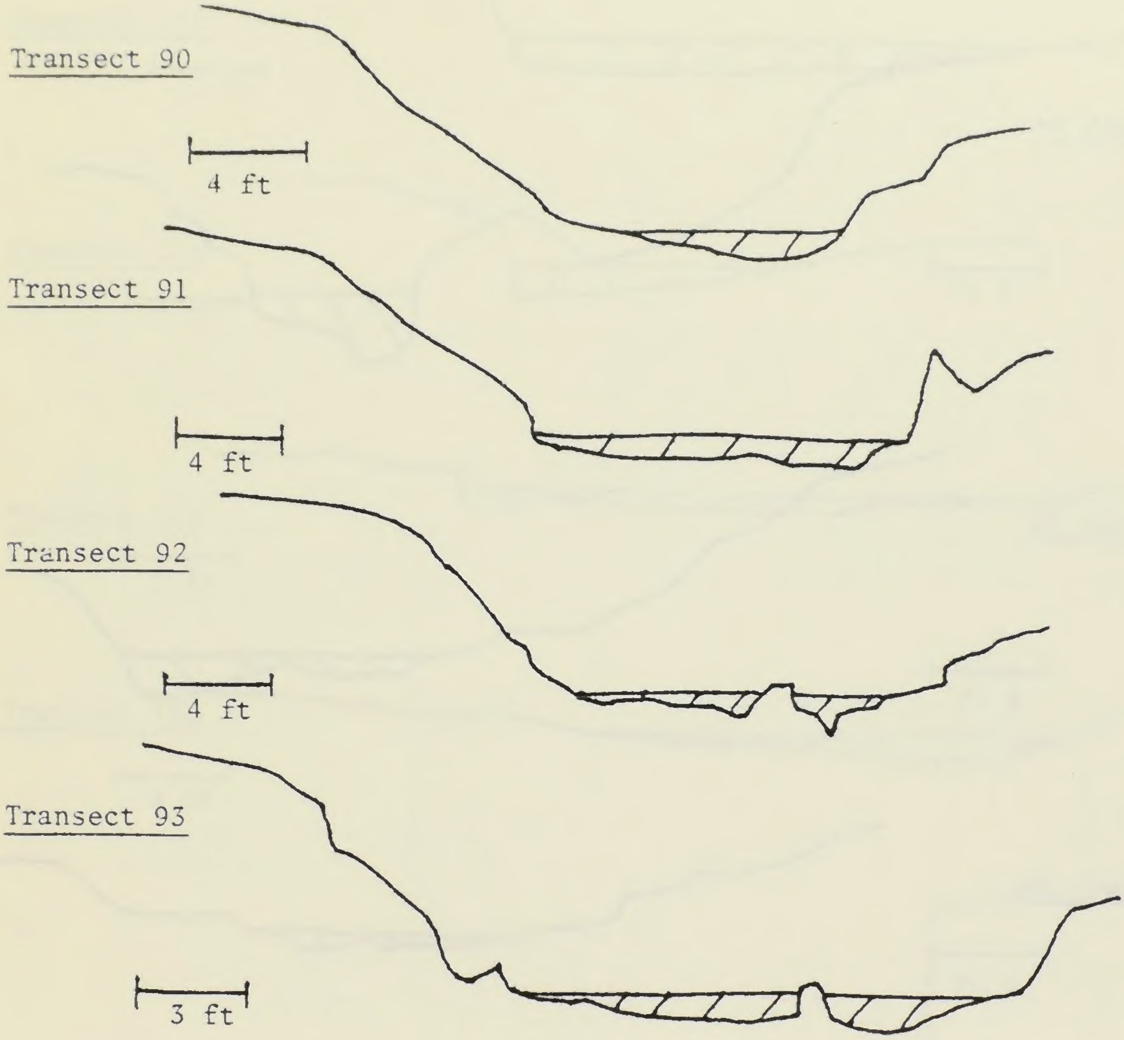



Figure 8. Channel cross sections for site 2, Tabor Creek in 1979.

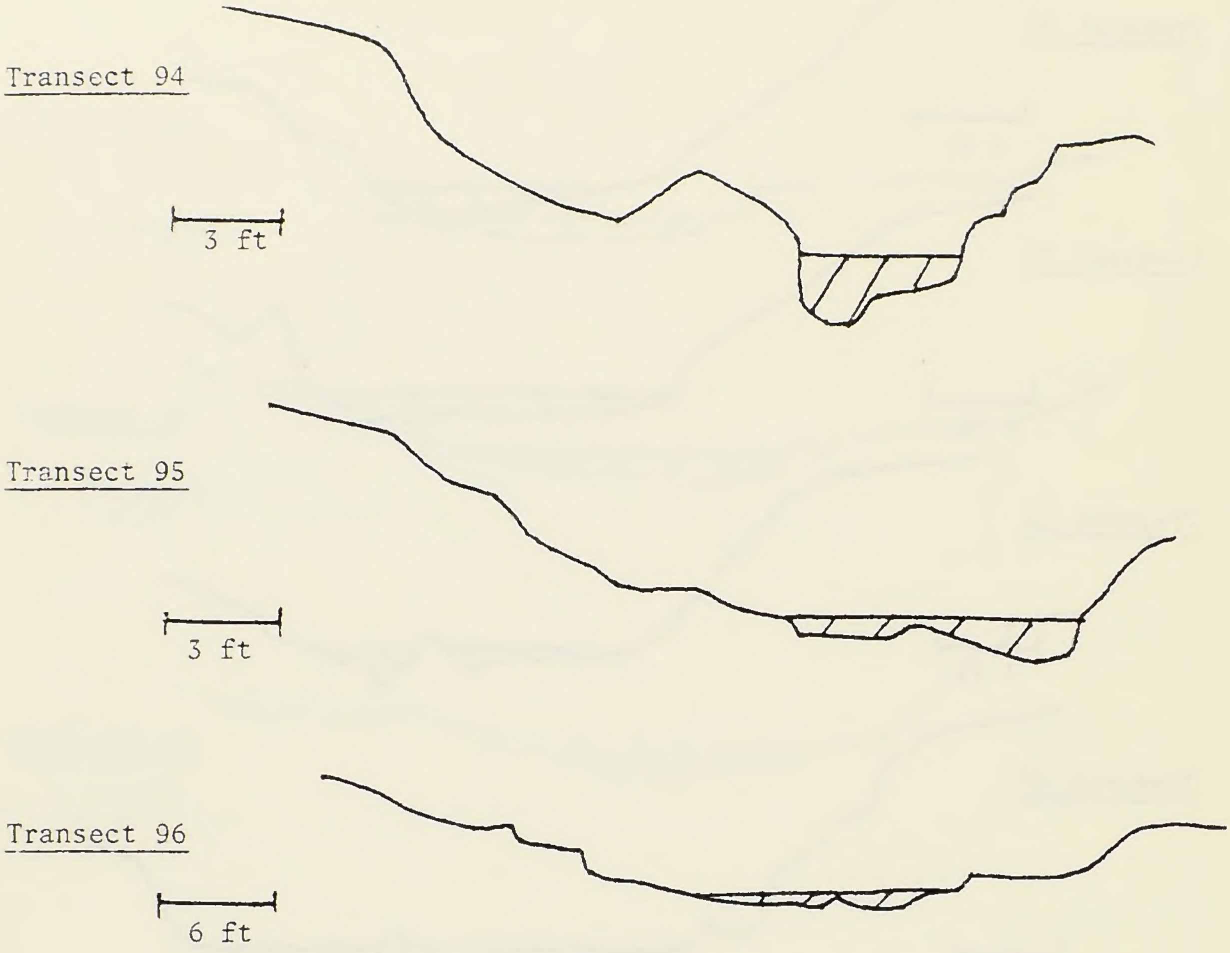



Figure 8. Continued.

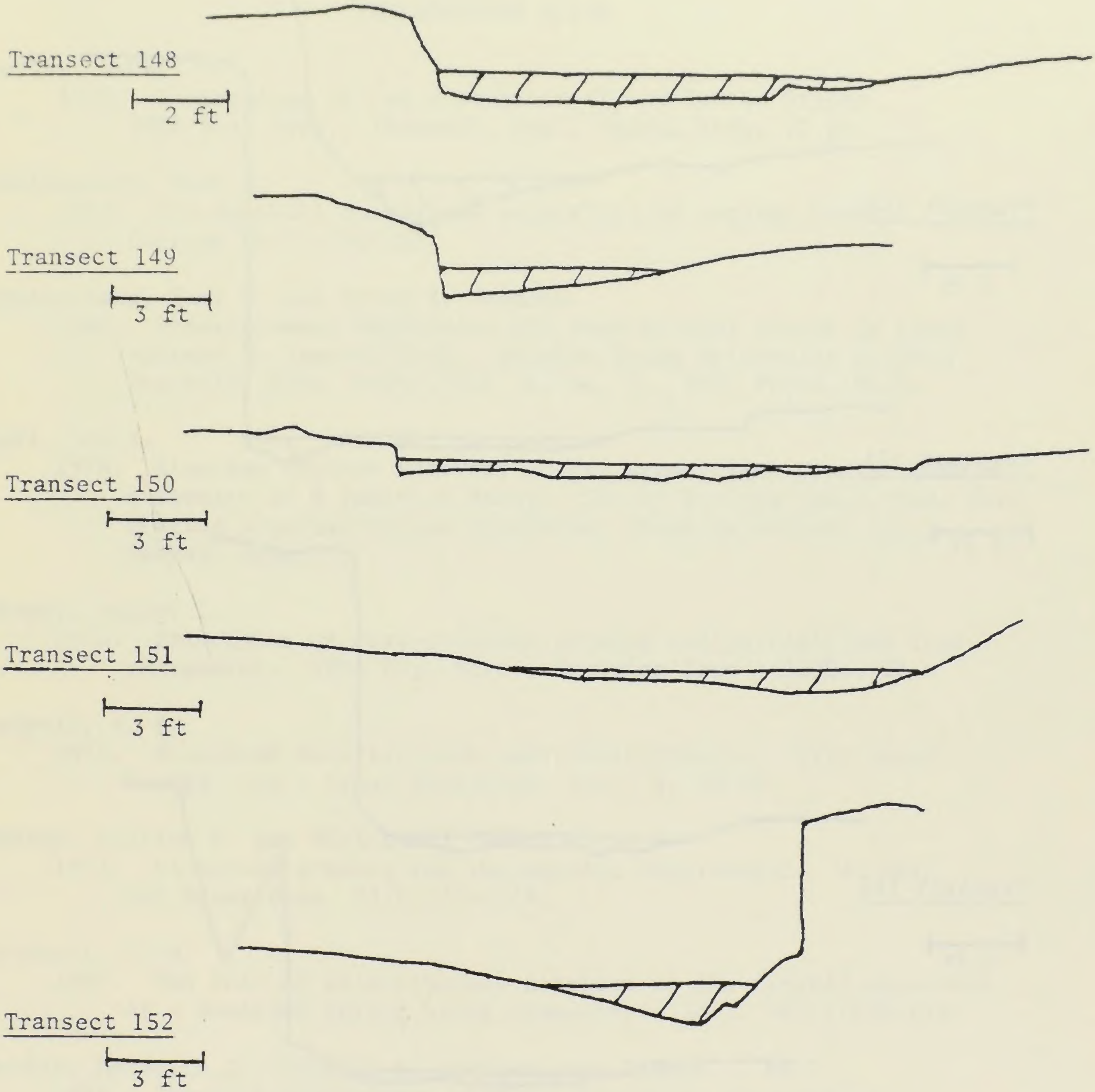



Figure 9. Channel cross section for site 3, Tabor Creek in 1979.

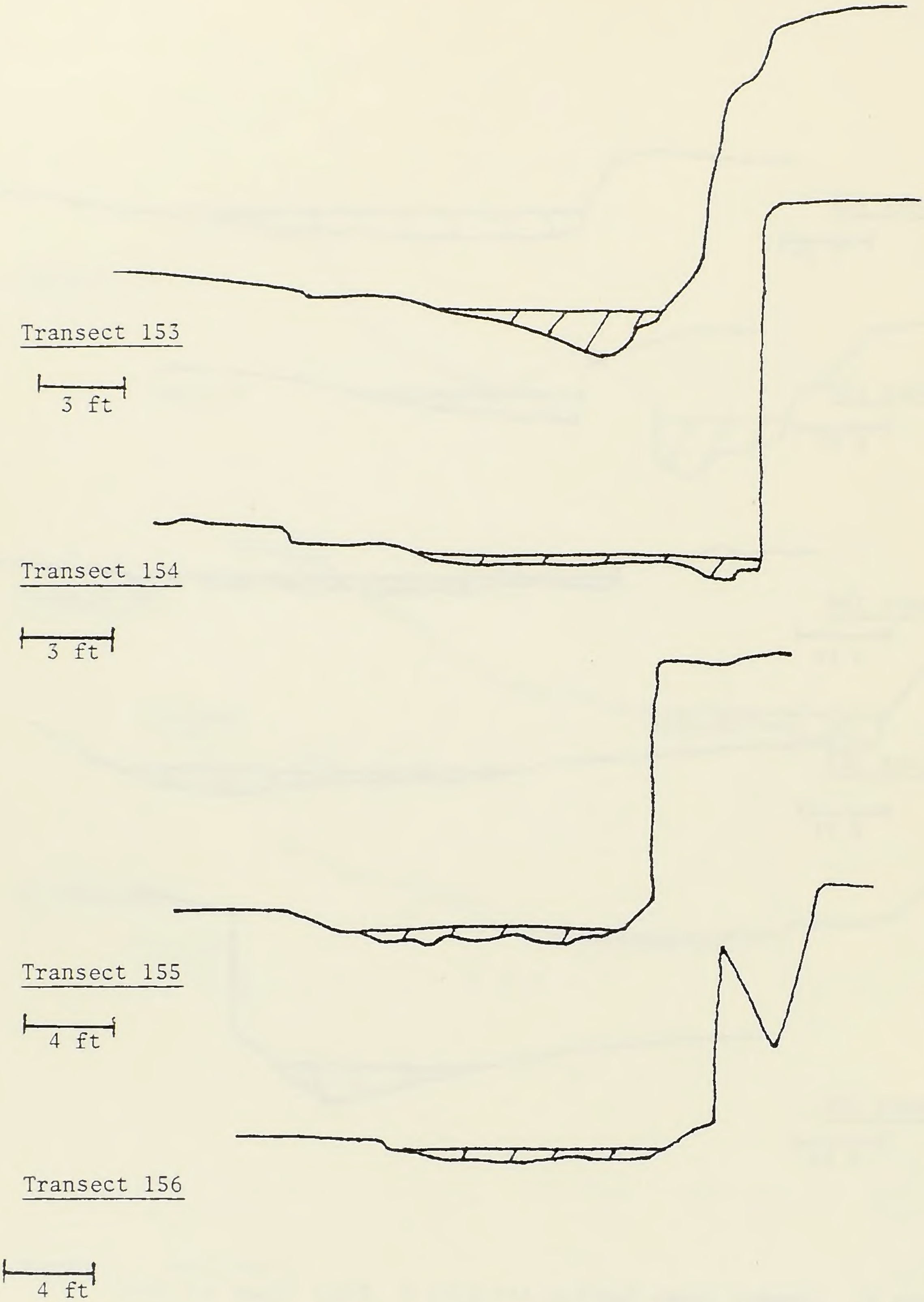



Figure 9. Continued.

## DISCUSSION

Initial results show a significant difference in many measurements between the grazed and ungrazed sites on Tabor Creek. Further data are necessary, however, to draw valid conclusions.

## PUBLICATIONS CITED


Bailey, Robert G.
1978. Description of the ecoregions of the United States. USDA For. Serv., Intermtn. Reg., Ogden, Utah, 77 pp.

Christensen, Earl M.
1963. The foothill bunchgrass vegetation of central Utah. Ecology 44(1):156-158.

Christensen, Earl M. and Hyrum B. Johnson
1964. Presettlement vegetation and vegetational change in three valleys in central Utah. Brigham Young University Science Bulletin, Biol. Serv., Vol. 4, No. 4., BYU, Provo, Utah.

Duff, Don A.
1978. Riparian habitat recovery on Big Creek, Rich County, Utah - a summary of 8 years of study. In: O. B. Cope (ed.) Proc. For. Grazing Riparian/Stream Ecosystem, Trout Unlimited, Inc., Denver, Colo.

Hormay, August L.
1970. Principles of rest-rotation grazing and multiple-use land management. USDA For. Serv., Training Text 4(2200), 26 p.

Leopold, A. S.
1975. Ecosystem deterioration under multiple-use. Wild Trout Manage. Sym., Trout Unlimited, Inc., p. 96-98.

Meehan, William R. and William S. Platts
1978. Livestock grazing and the aquatic environment. J. Soil and Water Cons. 33(6):274-278.

Minshall, G. W.
1967. The role of allochthonous detritus in the trophic structure of a woodland spring brook community. Ecol. 48(1):139-149.

Morris, Meredith J., Kendall L. Johnson, and Donald L. Neal
1976. Sampling shrubranges with an electronic capacitance instrument. J. Range Manage. 29(1):78-81.

Neal, Donald L., Pat O. Currie, and Meredith J. Morris
1976. Sampling herbaceous native vegetation with an electronic capacitance instrument. J. Range Manage. 29(1):72-77.

Patterson, Edna B., Louise A. Ulph, and Victor Goodwin
1969. Nevada's northeast frontier. Western Printing and Publishing Co., Sparks, Nevada, 702 p.

Platts, William S.
1974. Geomorphic and aquatic conditions influencing salmonids and stream classification with application to ecosystem classification. USDA For. Serv., Surface Environ. and Min. Proj., Billings, MT, 200 p.

Platts, William S.
1976. Validity in the use of aquatic methodologies to document stream environments for evaluating fishery conditions. Instream Flow Needs Proc., Vol. 2, p. 267-284, Am. Fish. Soc., Bethesda, Md.

Platts, William S.
1978. Livestock interactions with fish and aquatic environments: problems in evaluation. 43rd No. Am. and Nat'l. Res. Conf., Wildl. Manage. Inst., Wash., D.C., p. 498-504.

Platts, William S.
1980. Streamside management to protect bank-channel stability and aquatic life. (in press) USDA For. Serv. Intermtn. For. and Range Exp. Stn., Ogden, Utah.

Ray, Gary A., and Walter F. Megahan
1978. Measuring cross sections using a sag tape: a generalized procedure. USDA For. Serv. Gen. Tech. Rep. INT-47, USDA For Serv. Intermtn. For. and Range Exp. Stn., Ogden, Utah, 12 pp.

Stoddart, Lawrence A., and Arthur D. Smith
1955. Range management. McGraw-Hill, New York, N.Y., 433 p.

United States Department of Agriculture
1936. The western range. Letter from the Secretary of Agriculture. USDA, Senate Document 199, 620 p.

## SELECTED REFERENCES

Armour, Carl L.
1977. Effects of deteriorated range streams on trout. USDI Bur. Land Manage., Idaho State Office, Boise, Idaho.

Berry, Charles R., Jr.
1978. Impact of sagebrush management on riparian stream habitat. Utah Coop. Fish Res. Unit. (Presented at Sagebrush Ecosys. Sym., Utah State Univ., Logan, Utah)

Bidwell, R. G. S.
1974. Plant physiology. MacMillian Publishing Co., Inc., New York, New York, 643 p.

Branson, F. A., R. F. Miller, and I. S. McQueen
1967. Geographic distribution and factors affecting the distribution of salt desert shrubs in the United States. J. Range Manage. 20(5):287-296.

Christensen, Earl L., and Stanley L. Welsh
1963. Presettlement vegetation of the valleys of western Summit and Wasatch counties, Utah. Proc. Utah Acad. Sci., Arts., and Letters, Vol. 40, Pt. 2, p. 163-174.

Council for Agricultural Science and Technology
1974. Livestock grazing on federal lands in the 22 western states. J. Range Manage. 27(3):174-181.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren
1977. Intermountain flora. Vol. 6. Columbia Univ. Press, New York, 584 p.

Currie, P. O., M. J. Morris, and D. L. Neal
1973. Uses and capacities of electronic capacitance instruments for estimating standing herbage, Part 2, sown ranges. J. Br. Grassld. Soc. 28:155-160.

Dix, Ralph L.
1964. A history of biotic and climatic changes within the north american grassland. In: Grazing in Terrestrial and Marine Environments, Blackwell's Sci. Pub., Adlard & Son, Ltd., Dorking, England.

Egglor, Willis A.
1941. Primary succession on volcanic deposits in southern Idaho. Ecol. Monogr. 11(3):277-298.

Garrison, George A., Ardell J. Bjugstad, Don A. Duncan, Mort E. Lewis, and Dixie R. Smith
1977. Vegetation and environmental features of forest and range ecosystems. USDA For. Serv., Agric. Handb. 475, 68 p.

Harris, Grant A.
1977. Changing philosophies of rangeland management in the United States. J. Range Manage. 30(1):75-78.

Hitchcock, A. J.
1935. Manual of the grasses of the United States. USDA, Misc. Publ. 200, 1040 p.

Hunt, Charles B.
1967. Physiography of the United States. W. H. Freeman & Co. San Francisco and London, 480 p.

Jameson, Donald A.
1965. Phenology of the grasses of the northern Arizona pinyon-juniper type. USDA For. Serv. Res. Note TM-47, USDA For. Serv., Rocky Mtn. For. and Range Exp. Stn., Fort Collins, Colo.

Kothman, M. M.
1974. Grazing management terminology. J. Range Manage. 27(4):326-327.

Kuchler, A. W.
1964. Potential natural vegetation of the conterminous United States. (map and manual) Amer. Geog. Soc. Spec. Pub. 36, 116 p. map scale 1:3, 168,000.

Kuchler, A. W.
1966. Potential natural vegetation (map). USDI Geol. Surv. Nat'l. Atlas, Veg.; map scale 1:7,500,000.

Long, Robert W.
1974. Future of rangelands in the United States. J. of Range Manage. 27(4):253-255.

Mirov, N. T.
1967. The genus Pinus. The Ronald Press Co., New York, 602 p.

Nevada Department of Conservation and Natural Resources
1963. Water and related land resources, Humboldt River Basin, Nevada: report number four, Mary's River Sub-basin. 87 p. (In cooperation with the USDA Econ. Res. Serv., For. Serv., Soil Cons. Serv.).

Platts, William S.
1980. Effects of sheep grazing on a riparian-stream environment. (Manuscript proposed for publ. J. Soil and Water Cons.)

Stoddart, L. A.
1941. The Palouse grassland association in northern Utah. Ecology 22(2):158-163.

Thomas, Jack Ward, Chris Maser, and Jon E. Rodiek
1978. Riparian zones in managed rangelands - their importance to wildlife. In: O.B. Cope (ed.), Proc. For. Grazing Riparian/Stream Ecosystems, p. 21-31, Trout Unlimited, Inc., Denver, Colo.

Thornbury, William D.
1965. Regional geomorphology of the United States. John Wiley & Sons, Inc., New York, London, Sydney, 609 p.

USDI, Bureau of Land Management
1979. Otter Creek habitat management proposal (draft). USDI Bur. Land Manage., Richfield, Utah.

USDI, Bureau of Land Management
1979. Randolph planning unit grazing management final environmental statement. USDI Bur. Land Manage., Salt Lake City, Utah.

Vale, Thomas R.
1975. Presettlement vegetation in the sagebrush-grass area of the Intermountain west. J. Range Manage. 28(1):32-36.

Valentine, John F.
1971. Range development and improvements. Brigham Young University, Press, Provo, Utah, 516 p.

Varies, Kimery C., and Philip L. Sims
1977. The plant information network. USDI, Fish and Wildlife Serv., Office of Biological Services, FWS/OBS-77/38. (In cooperation with U.S. Environmental Protection Agency).